upper troposphere and lower stratosphere. As part of the Subsonic Assessment (SASS) Ozone and Nitrogen Oxides Experiment (SONEX), the objectives of the Ames team were (1) to measure the distribution of aerosol and cloud during the mission in order to determine the fraction of total aerosol that can be attributed to aircraft-generated sulfur, and (2) to determine the relevance of this aerosol as a marker of aircraft-influenced air and its effects on the regional climate.

An instrument based on the thermal volatilization of aerosols was fabricated and flown on the SONEX mission to discriminate sulfuric acid, ammonium sulfate/bisulfate, and nonvolatile aerosols during the mission. Using this instrument, a significant increase in the sulfuric acid aerosol was observed under conditions where other indicators suggested that the air parcels were influenced by aircraft exhaust. Most of these occurrences were above 9 kilometer (km) altitude. The sulfuric acid aerosols do not appear to measurably affect surface area and volume of the background aerosol because of their small diameter, and, therefore, do not appear to affect radiative transfer directly. Only a very small fraction of the nonvolatile aerosols could be identified as BCA.

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Quantifying Denitrification and Its Effect on Ozone Recovery

Azadeh Tabazadeh

Upper Atmospheric Research Satellite (UARS) observations indicate that denitrification occurs in the Antarctic, without significant dehydration, during mid to late June (see figure 1). In contrast, UARS data show no indication for the presence of large-scale denitrification in the Arctic, even during the coldest winters of the last decade (see figure 1). The fact that denitrification occurs in the Antarctic in a relatively warm month raises concern about the possibility for the occurrence of this event in a future colder, and possibly more humid, lower stratosphere, as a result of climate change and/or natural variability, and its subsequent effect on ozone recovery. Polar stratospheric cloud (PSC) lifetimes required for Arctic denitrification to occur in the future were contrasted against the current Antarctic cloud lifetimes during early and mid to late June. Ozone sensitivity calculations show that widespread denitrification can enhance future Arctic ozone loss by about 40% during the coldest winters of the next century.

It is well known that PSCs play an important role in the formation of the springtime Antarctic "ozone hole" by activating chlorine and denitrifying the stratosphere. Because similar levels of active chlorine concentrations have been measured in both polar vortices, the lack of extensive denitrification observed in the Arctic has been speculated to be one of the main factors currently preventing the formation of an Arctic "ozone hole." At Ames, and for the first time, a quantitative study was done on the denitrification process that explains why this event currently occurs extensively in the Antarctic and not the Arctic, using data obtained from numerous different instruments onboard the UARS.

Until now, a few studies have implied that Arctic denitrification, during the coldest winters of the last decade, has already contributed significantly to the depletion of ozone inside the Arctic vortex. On the other hand, a wealth of available information suggests that the apparent and simultaneous loss of both ozone and reactive nitrogen in the Arctic is often purely a result of dynamical mixing of different air masses with high and low values of both species that is unrelated to denitrification. Also, most in situ and

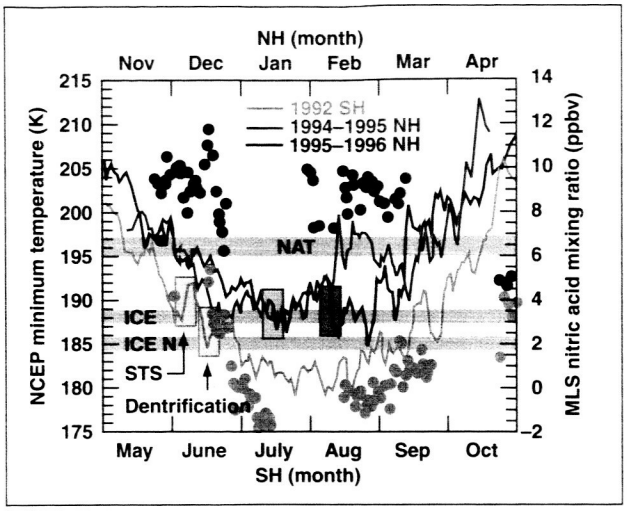

Fig. 1. Minimum temperatures are shown for a selected number of polar winters at the 50-millibars (mb) pressure level, which is near the 450 K potential temperature surface. The periods for ternary PSC formation and denitrification during the Antarctic winter of 1992 are marked in the figure as blue boxes. The NAT (nitric acid trihydrate) and ice envelopes (shaded gray) show temperatures at which nitric acid and water saturate to form nitric acid trihydrate and water ice particles, respectively. The ice nucleation envelope marks the temperature at which ice clouds can nucleate in the stratosphere. The critical temperature envelopes are calculated for nitric acid and water vapor mixing ratios of 9 to 12 parts per billion by volume and 4 to 5 parts per million by volume, respectively, based on in situ observations. Two Arctic study periods are also marked in the plot as magenta and gray boxes for the 1994–1995 and 1995–1996 winters, respectively. Symbols shown are the time series of microwave limb sounder gas-phase nitric acid averaged and binned between the 75–80° S and 75–80° N for the Antarctic and the two Arctic winters, respectively.

balloon data sets showing denitrification in the Arctic are collected either directly over or downwind of mountainous terrain (mainly over Greenland and Norwegian mountains), where lee waves could strongly affect the local reactive nitrogen (and/or water vapor) profile through small-scale cloud processing. However, the fact that satellite data show no indication of widespread denitrification in the Arctic at present suggests that the local perturbations caused by lee waves are not of global or even regional significance.

To resolve the controversy between space, in situ, and balloon observations regarding denitrification in the Arctic, a new concept was introduced at Ames that compared and contrasted "PSC lifetimes" between the two hemispheres to investigate whether PSC lifetimes could have been long enough in the past Arctic winters to have led to widespread denitrification. The concept of PSC lifetime provides new insights into how long a PSC must persist in the winter for the denitrification process to occur, and why the event currently occurs only in the Antarctic. Further, it is planned to show that future forecasted perturbations in temperature and water vapor can increase Arctic PSC lifetimes to the point where denitrification can occur during the coldest winters of the next century with important implications for Arctic ozone recovery.

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Reduction of Trade-Cumulus Cloud Cover Due to Solar Heating by Dark Haze

Andrew Ackerman

The radiative forcings of aerosols represent a leading source of uncertainty in recent assessments of radiative forcings due to industrial activity. Although aerosol residence times are short (approximately one week or less, compared to ~50 years for carbon dioxide molecules), and they influence the radiation budget only during the day, it is estimated that by increasing reflection of sunlight, the cooling effects of aerosols may offset the radiative forcing (globally averaged). The traditional radiative forcings due to aerosols are (1) direct, by which aerosols directly scatter and absorb sunlight (cooling and heating effects, respectively), and (2) indirect, by which